PLM-ENHANCED ENGINEERING EDUCATION

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ABSTRACT
As the processing and management of engineering data and workflows have become one of the biggest challenges in industry, a need has emerged for including PDM and PLM (Product Data management and Product Lifecycle Management) into mechanical engineering programs at universities.
This paper describes the concept of PLM education at RWTH Aachen University, entailing a project called ProVerStand ("Produktentwicklung über Verteilte Standorte" - "Product Development Involving Distributed Locations") initiated by the Chair and Institute for Engineering Design (ikt). The aim of this initiative is to provide universities and similar institutions access to state of the art PLM systems, such as PDMS, CAE and CAD. With the help of governmental funding, the ikt has been able to share its hardware and software implementation with all universities within the federal state of North Rhine-Westphalia (NRW) in Germany at no cost for the participating partners. Since the project's start in 2002, it has taken proportions that can compete with the biggest industrial-scale applications, featuring 45.000 registered users and continuous software upgrading and migration.

Keywords: PLM education, CAE, PDMS

1 TOWARDS THE IMPORTANCE OF PLM IN ENGINEERING EDUCATION

Since engineering documentation has become rather digital also the associated processes of product development have undergone a remarkable evolution in the last decades. Physical archives of technical drawings have been substituted by powerful server clusters and substantial software applications. The technical progress also allows a better communication and collaboration between all departments involved in the product lifecycle. In the early 90s the foundation for a better integration of designers in the PDP (Product development Process) was set through the availability of CAD tools respectively the professional implementation of 3D modellers. From that point in time, the integration of extensive knowledge and information concerning related requirements, production features, service regulations etc. into the digital product was technically existent. In order to allow a company spanning reuse of product data and product models, databases with comprehensive application layers have taken over the role of engineering data management. With multiple business process facilitating functionalities, PLM-supporting systems, such as PDMS (Product Data Management Systems), go far beyond the actual storage of data. The aim is to incorporate essential knowledge from each phase of the product lifecycle into the virtual model and to provide a sustainable and consistent set of data which is accessible according to predefined role and rights management [1]. Besides, the automation of processes in terms of system based workflows has become a crucial backbone for streamlining the product development and increased the transparency of responsibilities and assignments. But also external market requirements caused by globalization lead to a cumulative outsourcing, offshoring or decentralization of engineering resources [2]. PLM offers a large variety of operative and strategic means to overcome the gaps of collaboration among different time zones, companies and engineering cultures.

As not only OEMs but also SMEs have to face these new challenges, a broad integration of PLM methods into the mechanical engineering curricula helps to better prepare prospective students to cope with industry's needs. Contemporary tools and practice-oriented concepts play a major role in this context. The demand of shorter educational cycles and decreasing monetary resources at most of the universities, force the faculties to break new field. Thus it is more and more important to provide opportunities for students to enhance their knowledge. An integration of powerful tools enables

education along the whole process chain from design, followed by simulation of mechanical behaviour, NC-programming up to the management of development data within a PDMS.

2   THE PROVERSTAND INITIATIVE

2.1 PLM Services for the universitary environment

The foundation of ProVerStand in the year of 2003 has been the initiation of a university-spanning collaboration network focussing on the integration of PLM into the curricula [3]. Since that time a number of 44 institutes at 17 universities throughout the federal state of North Rhine-Westphalia (NRW) joined this community. In the last seven years notable funding has been acquired to provide the technical basis needed to serve a large number of students, researchers and faculty. About eight mill. Euros have been spent for licensing, server architectures and network infrastructure. But this figure does not take the staff appropriations of actual 14 personnel into account, which take care of the unique installation.

As professionally managed PDMS are not affordable for minor institutes, one of the most important objectives was to gain access to state-of-the-art applications at no cost for all interested universities. The use of PTC Windchill as PDMS respectively CPC (Collaborative Product Commerce) allowed having servers set up at a central location without the need for a client installation at full functionality. Licensing for 45.000 named users for the Windchill application means that there are 45.000 potential support requests in case software modules need to bee installed or configured by students. In comparison to company-managed IT-structures, students tend to have a large variety in concerns of operating systems and interacting applications. As also the distribution of the software was very time-consuming in the early years, mostly compact disks were handed over, a fully internet based technology was the favoured scenario. Additional software along the product lifecycle has been licensed over the years. According to the principles of PLM, high value was set on the compatibility and integration of the different tools. An overview of the current applications of the ProVerStand-initiative is displayed in Table 1.

Table 1. Licensing of ProVerStand

Software	Number & sort of licence	
Windchill (ProjectLink/PDMLink) v8	45.000	named
Windchill (ProjectLink/PDMLink) v9.1	11.500	concurrent
Pro/Engineer Wildfire	10.000	concurrent
Mathcad	12.000	concurrent
Mathcad Student Homeuse	23.000	single user
Arbortext	100	concurrent
Elearning PTC University	5.000	concurrent

A unique server cluster, consisting of more than 40 machines in the 2010 setup (Figure 1), allows professional backup solutions and testing scenarios. The large number of users also forces to have load balancing for the different servers. Additionally a few hardware components have been virtualized to allow scaling and to cover peak demands.
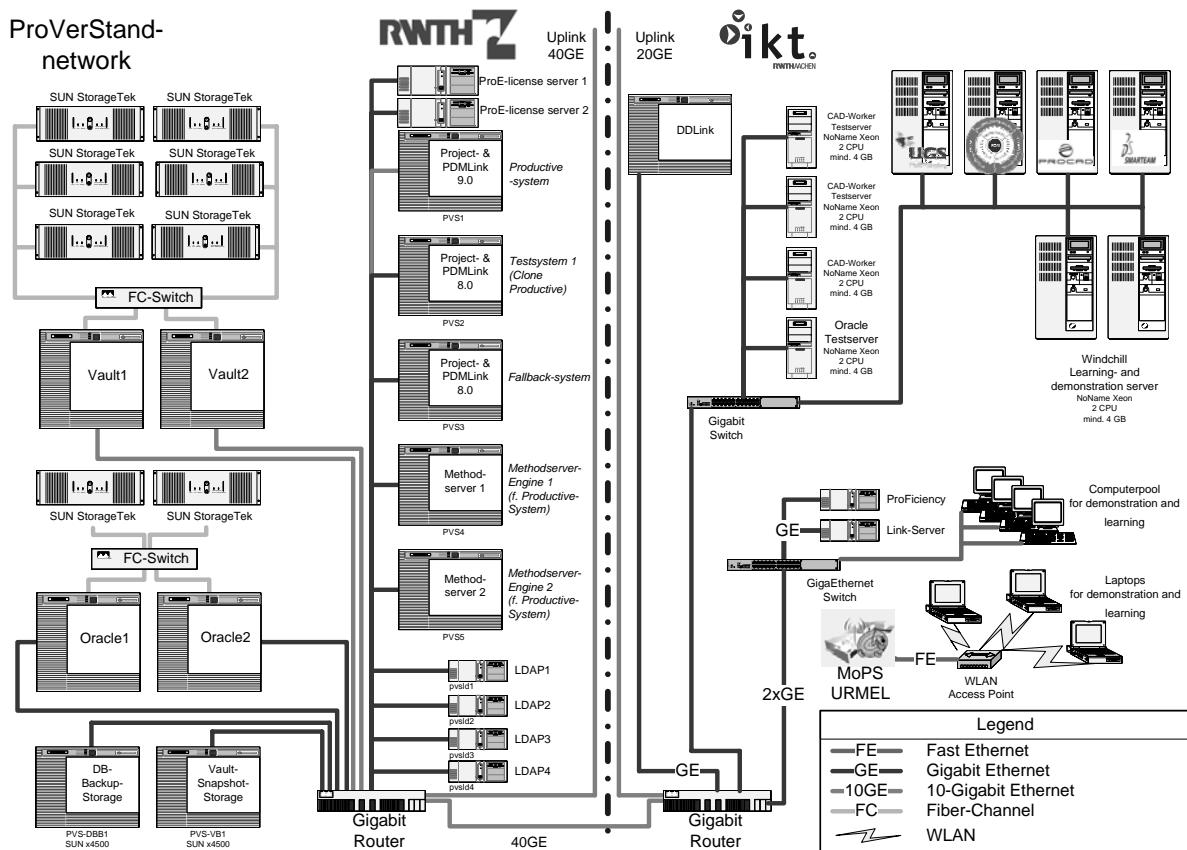
Figure 1. ProVerStand Server-setup

By providing access to e-learning platforms in order to get advanced qualification, ProVerStand helps the universities more to focus on teaching the fundamentals of engineering and to strengthen research and development. To ensure a competitive education of tomorrow's engineers the students need access to powerful workstations which match the requirements of today's 3D-CAX applications. ProVerStand provides these machines and offers flexible teaching scenarios with multi-room courses to guarantee efficient use of personnel and room capacities and emphasizes the use of new media.

3   PLM IN ME EDUCATION AT RWTH AACHEN UNIVERSITY

With the change in the German higher education system, as a result of the "Bologna Process" in 2007, the diploma has been substituted by the international bachelor/master study program. In order to keep the essential elements of PLM in each of the study phases, a pyramid model (Figure 2) representing the advancement of PLM-related knowledge and the application of associated software-tools has been developed. Basic skills are imparted in the early steps when PLM-supporting systems are first introduced in the 2nd semester. The use of PDMS in combination with the creation of design data and routing functionalities is also part of the examination. A CAD task is assigned to each student which can be worked on alternatively with Siemens NX or PTC Pro/E Wildfire. After the work is completed, the student initiates an approval routing to start the review of his examination. In the year of 2009 a number of 1420 students took this class in the spring semester. Once this course is passed, students of the occupational area of "Design Engineering" enhance their theoretical background on fundamentals of Product Lifecycle Management in the course "Systematic Engineering Design (SED)". Strategic aspects with focus on the flow of data and information as well as organizational structures are covered by SEDII, which is a compulsory subject in the master program.

Additional courses, particularly "Design of Machines and Devices (KvMG)" as well as "Collaborative Product Development", set the active participation of the students to the next level. Within KvMG an engineering assignment is provided by an industry partner and should be at least digitally prototyped at the end of the second course term. Team formation with different responsibilities on the project,

such as packaging, project management, electric components etc., forces the students to make their collaboration data available for the design of interfaces and interaction [5]. At each significant milestone reviews with participation of the customer take place and ensure valuable feedback for the students. In the last year the conceptualization and the detailing have been very promising, so that at the end of the course the decision on manufacturing the machine for textile processing has been made.

As Product Development gets more and more international and multidisciplinary, the skills needed for the future employees also change considerably. Since most problems in complex engineering projects occur due to insufficient collaboration and exchange of information, a need to provide realistic tasks in the universitary education arises. The Institute for Engineering Design (ikt) at RWTH Aachen University has been conducting a course on Collaborative Engineering (CoPro) incorporating an active learning concept [4] for a few years now. The concept requires a design task that can be worked on by the students in a collaborative and competitive situation, because only such conditions allow for challenges typical for projects spread over numerous sites to arise naturally. The aim was to include students from other countries, if possible even from other domains such as Creative Design in the project associated with the course that covers methods and tools for Collaborative Product Development. This aim has been realized in the summer semester of 2008 for the first time. In 2010 the course is in its third year with the Departments of Industrial Design and Mechanical Engineering of Hongik University, Seoul, Korea [6]. The actual collaboration through time zones, languages and cultural diversity happens enhanced by internet based technologies. webmeeting, videoconferencing and of course data sharing through PDMS are essential tools to sustainably merge all relevant information for the creational process.
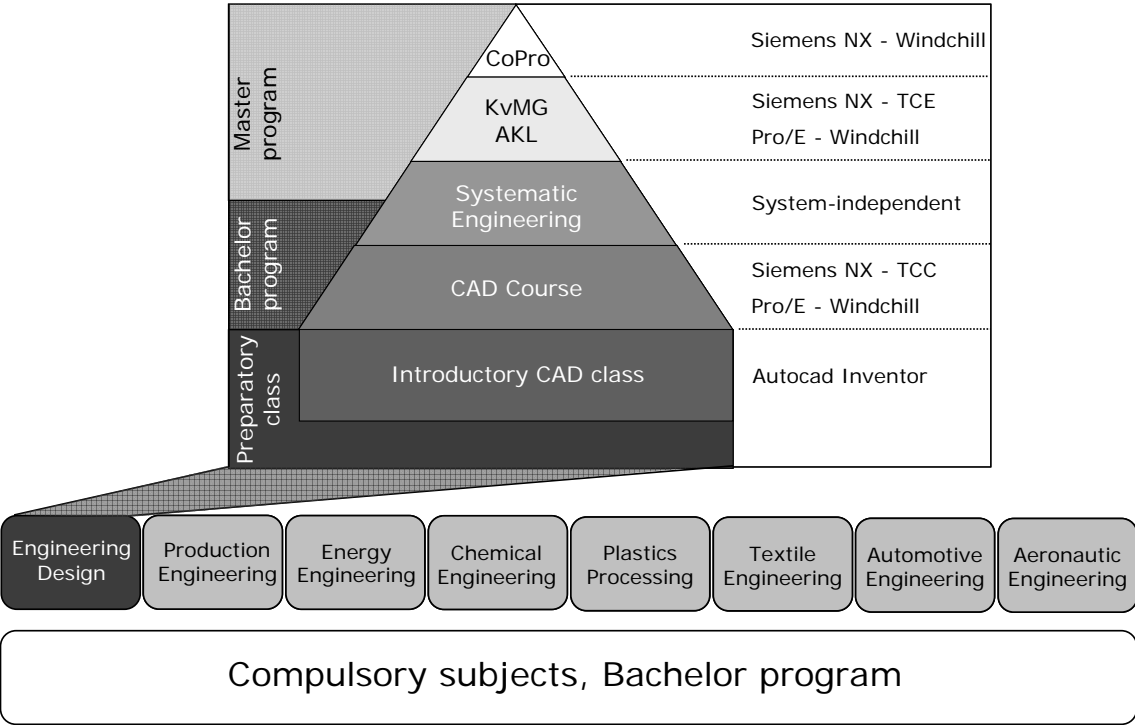

Figure 2. PLM education scenario

4 PLM BASICS: PROJECT THESIS WITHIN THE BSC PROGRAM

Examination regulations in the bachelor studies specify a project thesis with duration of 90 days. With regards to the number of written examinations in the first 3 years of the curriculum, students are encouraged not to start before the 6th term. This means, basic knowledge on electronic data management through the use of PDMS in the 2nd semester is available and well suited to ease the administrative process of the mandatory projects. With more than 50 chairs within the ME department of RWTH Aachen University and no centralized announcement board for project proposals, identifying an interesting topic has been quite time consuming for students in the past. To make

choosing a project even more complex, the new curriculum calls for team work, which means a group of students has to be assembled before it can start. The new PDMS implementation allows scanning all project proposals by full-text search and different attributes, such as "constructive or theoretical work" and "involvement of industry companies", help to preselect from a large offer of proposals.

Using a separate discussion thread for each project proposal, the students are given the chance to conveniently kick off the process of group formation. The implemented interface to the university's identity management as well as the mail server enables the subscription to any project proposal and discussion thread. This is one way students can express their interest to a project and let others know about their intention. Once enough participants enlisted for a topic, they can approach the specific mentor to get additional information. Due to the amount of proposals and the acceptance of the students, a workflow has been implemented, which sends a system-generated email to the proposal author to remind him to double-check the relevance of the text after 90 days of display. After that period, the lifecycle of the document changes to "dated" and is invisible for the students until the author sets back the state to "released" or in case the author does not check the document within 30 days of notification, the file will be automatically removed from the database. An overview on the document lifecycle and access is depicted in Figure 3.
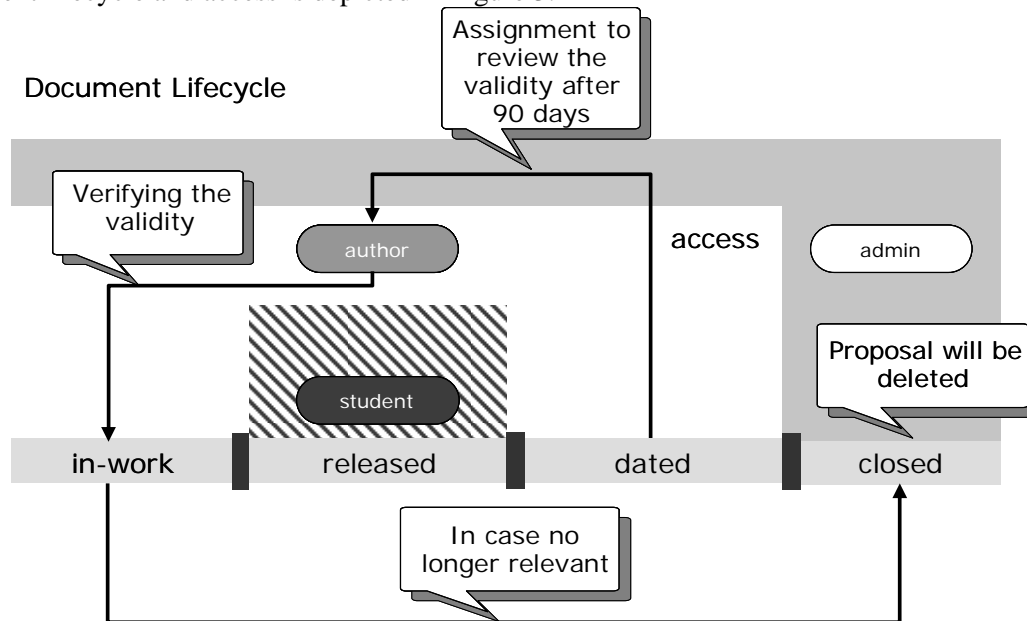

Figure 3. Document lifecycle: project proposal

During the in-work phase of the thesis, the PDMS can be used as a collaboration space and provides a framework through process templates, which are supported by milestones and additional features such as notification workflows. The project mentor invites the interested students in a kick-off meeting to join a project on the PDMS server. Using predefined roles for the team members, students can easily be supplied with appropriate rights to collaborate for the duration of the project. When the project is initiated, a predefined project plan with standard milestones for the upload of a detailed activity plan and the final thesis document is activated. An interface to MS Project is implemented and allows and automated transfer of external plans. The Windchill system also provides the functionality of webmeetings through the "Webex"-module and has an integrated CAD-file viewer with redlining, exploded view, measuring etc.

Within a timeframe of 3 days before the final project deadline, the student team lead gets an automatic reminder for the check-in of the relevant document. Once the final document is uploaded, a routing is initialized and assigns the review to the mentor.

Involved faculty can use the reporting functionality, which gives an overview on the percentaged completion of the project. Also missed deadlines and the number of uploaded documents can be monitored.

In order to ensure purposeful application of the system, faculty as well as doctorates are encouraged to take part in a half-day introductory course. It is seen as an appealing teaching concept that this course is offered through the "Centre for doctoral studies" and hence is accredited to the PhD-program. Additional skills can be earned by optional internet-based courses entailing assessment and certification. ProVerStand has licensed 5000 concurrent users for professional elearning modules covering all relevant applications from the beginners to the administrative level.

5   SUMMARY AND OUTLOOK

PLM and collaborative work commonly prevalent in industrial practice require appropriate education of engineering students. Often monetary as well as limited human resources are a major hindrance in keeping up with the industrial progress and needs. The Chair and Institute for Engineering Design, ikt at RWTH Aachen University initiated the project ProVerStand to overcome these limitations and offers state of the art PLM software and services to currently 17 universities in Germany. Since offering access to tools is just a part of the initiative, a concept for comprehensively integrating PLM into the curriculum has been introduced. Starting with PLM teaching even before the actual bachelor program and extending the range to the master and PhD courses, a continuous and integrated approach has been strived for.

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